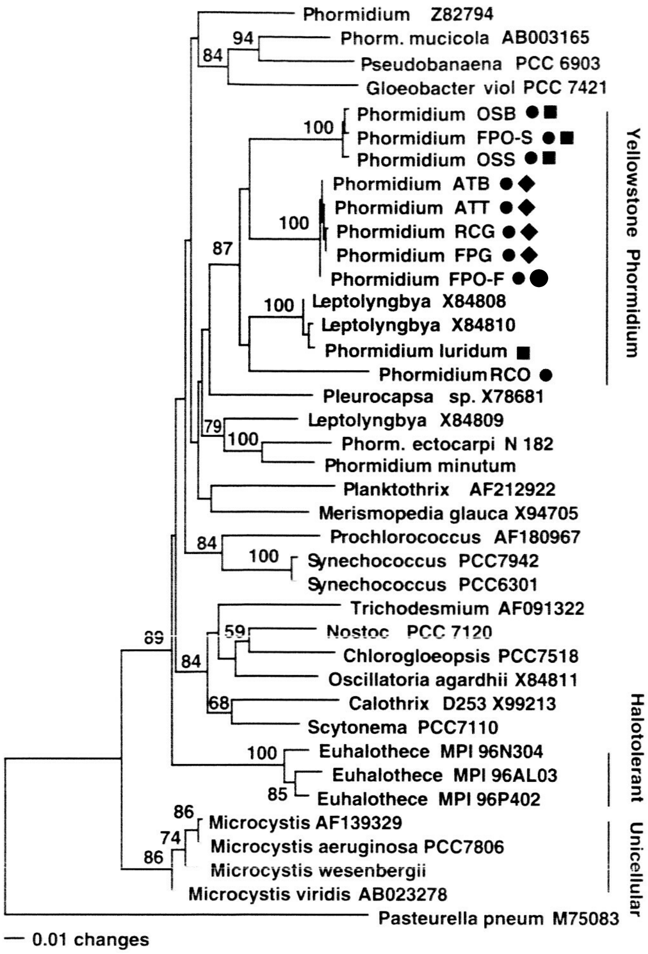

Fig. 1. Phylogenetic tree constructed using the DNA sequences for the 16S ribosome of Yellowstone Phormidium isolates (l), and cyanobacterial species chosen from GenBank to represent major clades showing Phormidium group synthesizing 2-methylhopanoids (n), and the group synthesizing only nonmethylated hopanoids (u).

Astrobiology Leonid Meteor Shower Mission

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The anticipated 1999 Leonid meteor storm provided a unique opportunity to study the nature and composition of meteoroids. Because the timing and intensity of the Leonid showers can be determined to within acceptable parameters to plan observing campaigns, NASA Ames Research Center and the United States Air Force (USAF) jointly sponsored the Leonid Multi-Instrument Aircraft Campaign (Leonid MAC). The airborne campaign produced a wealth of data, images, and spectra that will result in new insights on the nature of cometary debris and the significance of meteors as a seeding mechanism for organics on young planets.

The Leonid meteor storm begins its long journey as cometary ejecta from a periodic comet named 55P/Tempel–Tuttle. Comets are known to contain both simple and complex organics that predate the evolution of the solar system. The complex organics are thought to remain part of the meteoroids after ejection when the cometary ices have evaporated. Each year our present day Earth passes through an estimated 40,000 tons of such meteoric debris. At the time of the origin of life, about 4 billion years ago, that influx was a hundredfold larger. Earth was void of the basic organic compounds necessary for the origins of life. Many have postulated differing theories ranging from complex, time-dependent geochemistry to singular catastrophic impact events to account for the source of organics. Meteors provide a potential alternative pathway for their introduction.

The 1999 mission had two principal objectives: (a) to provide insight into the origins of life on Earth; and (b) to assess the impact threat of a meteor storm to satellites orbiting the Earth. It followed a successful NASA-sponsored mission in 1998. The NASA and USAF partnership provided 35 scientists from seven different nations two platforms for stereoscopic observations under the best possible observing conditions right under the peak of the shower. The Flying Infrared Signature Technology Aircraft (FISTA) and the Airborne Ranging and Instrument Aircraft (ARIA) were operated by the USAF.

Techniques employed included: state-of-the-art high-definition TV technology, near real-time flux measurements using intensified video cameras (the results of which are shown in figure 1), and spectroscopic measurements of meteors and persistent trains at wavelengths spanning from the near ultraviolet to the midinfrared (mid-IR). Results include the first spectroscopic record of the afterglow of a meteor fireball, shown in figure 2, and the first near- and mid-IR spectra of meteor trains. The first video record of a meteor storm also shows lightning near the horizon, and it may contain clues to whether meteors trigger "sprites" and "elves."

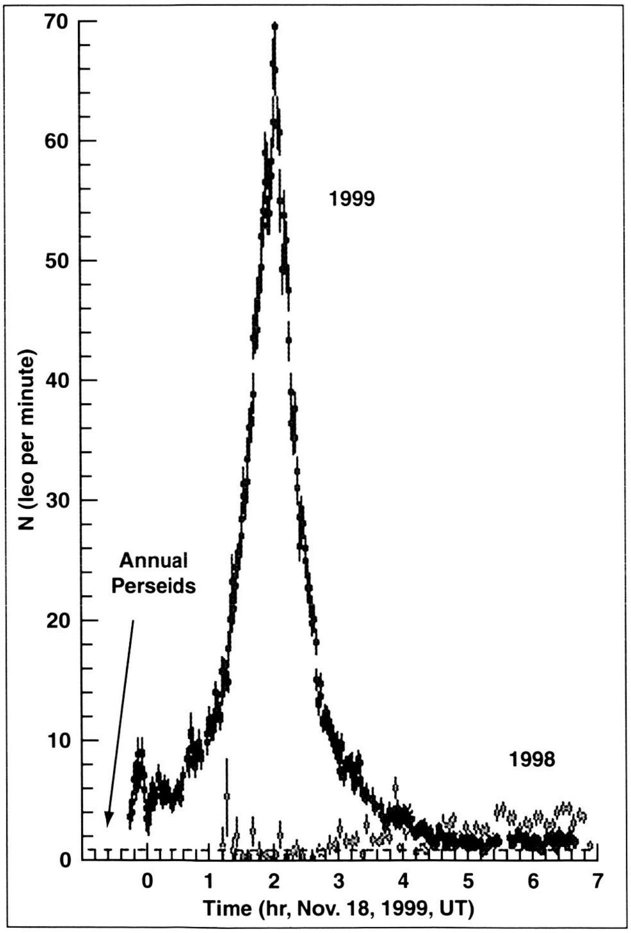

Fig. 1. Rate of Leonid meteors in 1998 and 1999 compared to that during the annual summer Perseid shower (dashed line at the bottom).

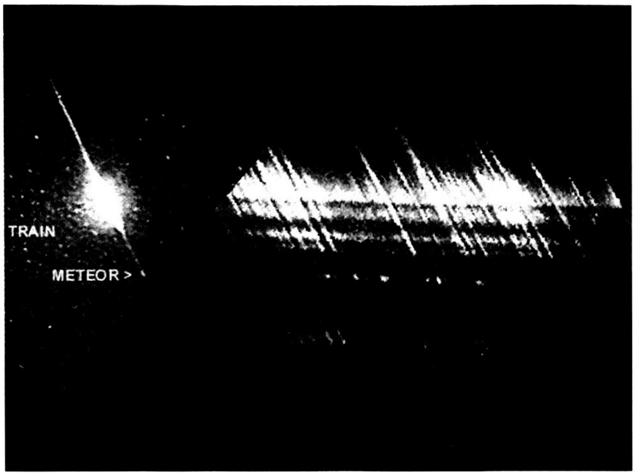

Fig. 2. The meteor and afterglow of the 04:00:29 UT Leonid fireball of Nov. 18, 1999, was detected by an Ames' slitless LLLTV spectrograph in the wavelength range from 0.4 to 0.9 micron.

Ames contributed to this mission new and highly successful approaches to meteor and meteor train spectroscopy at visual wavelengths. Interplane meteor targeting and spotting software were deployed to facilitate stereoscopic location and observation of significant meteor events for the first time. The mission also demonstrated a virtual mission-control concept, where aircraft tracking, status, and telemetry were all accessible through an internet browser. An INMARSAT datalink from the ARIA aircraft was combined with local-area network architecture on both aircraft to create the first airborne extranet connected with NASA Ames Research Center and other ground-based scientists and observatories for near-real-time flux reporting.

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